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Technology Gap and Yield Assessment of Climate Resilient Practices on Chickpea

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ABSTRACT

The present investigation on climate resilient practices (CRP) was carried out at the three villages of Jhunjhunu district of Rajasthan during rabi 2022-25. The intervention demonstrated improved variety (GNG-2144 & GNG-2171), optimum seed rate, seed treatment, line sowing, nutrient management, water management at critical stages, weed management and application of IDM module for the management of disease. The study resulted that CRP had a positive impact on yield of chickpea compared to farmer practices. During the study period the average yield of chickpea increased under demonstration was 18-21% respectively. The technology assessment index such as technology gap (7.64 q ha-1), extension gap (2.28 q ha-1) and technology index (33.66%) showed higher yielded after adoption of technology. The average economic benefit: cost ratio was higher (2.07, 2.32 and 2.30) under the demonstrated field compare to farmers practices (1.69, 1.89 and 1.90), respectively. Overall, the adoption of the climate-resilient practices intervention viable in the terms of yield and economic returns.

Keywords: Chickpea, Climate resilient practices, Profitability, Yield

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INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the most important rabi pulse crops grown in arid and semi arid region of India. Nearly World's 70% of chickpea production contributed by India, with major growing states like, Madhya Pradesh, Rajasthan, Maharashtra, and Uttar Pradesh (FAO, 2022). Within Rajasthan, chickpea is primarily cultivated under rainfed conditions in the Transitional Plains of Inland Drainage Zone of Agro-Climatic Zone, a region characterized by erratic rainfall, sandy loam soils, and high inter-annual climatic variability (Jat et al., 2020). Despite its ecological adaptability, chickpea productivity in this zone remains below the national average (12.6 q./ha (DES 2023, MOAF&W, GoI)), largely due to climate variability, moisture stress, and limited adoption of improved production technologies (Kumar et al., 2021). Farmers often rely on traditional practices with local varieties, abnormal seed rates, imbalanced fertilization and inadequate pest management along with changing climate abnormalities like extreme frost, chilling injury, drought, uneven rainfall, unseasonal rainfall, heat stress at flowering and maturity stage of chickpea which collectively contribute to a significant yield gap between potential and actual yields (Rathore et al., 2020). Studies in Rajasthan have reported yield gaps ranging from 25% to 45%, primarily driven by abiotic stresses and management inefficiencies (Meena et al., 2022).

To address these challenges, climate-resilient practices (CRP) such as improved short-duration, frost-tolerant varieties, conservation tillage, weed management, integrated nutrient management, pest management and efficient water-use techniques are being promoted under the National Innovations on Climate Resilient Agriculture (NICRA) initiative by ICAR-CRIDA since 2011. These interventions aim to enhance adaptive capacity, stabilize yields and improve input-use efficiency in rainfed agro-ecosystems. Recent evidence suggests that the adoption of climate-resilient technologies can reduce yield variability by 20–30% and improve water-use efficiency by 15–25% in pulse-based systems (Chaudhary et al., 2021 and Singh et al., 2023). However, the actual field-level impact of these interventions on the technology gap, extension gap, and yield gap for chickpea in Rajasthan's transitional plains has not been extensively quantified. Understanding these gaps is essential for designing targeted extension strategies and promoting large-scale adoption of climate-smart technologies. Therefore, the present investigation entitled technology and yield gap assessment of climate resilient practices on chickpea was undertaken to evaluate the performance of improved, climate-resilient technologies vis-à-vis farmers' practices, quantify technology, yield gaps and assess the economic feasibility of these interventions.

MATERIALS AND METHODS

The NICRA Front Line Demonstrations (FLDs) programme was conducted during rabi 2022-25 seasons by KVK

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Jhunjhunu, Rajasthan to popularize the climate resilient agriculture practices for chickpea production under changing climate scenario and sustaining the chickpea production under rainfed condition. For imposing FLDs farmers' were selected following the survey suggested by Choudhary (1999) with total 70 demonstrations in 28 ha area @ 0.4 ha per farmers. The package and practices of climate resilient practices like-resilient variety (GNG-2144 & GNG-2171), optimum seed rate (60-80 kg/ha), line sowing, seed treatment and basal dose of fertilizer on the basis of soil test value, pre emergence application of pendimethalin 500g a.i. per ha followed by one hand weeding at 30-35 days after sowing (DAS), irrigation by sprinkler system and plant protection measures (Table 1). Regular and timely field visits by scientists ensured effective guidance to farmers regarding the appropriate application of inputs and improved crop management practices. Various extension activities such as field days and on-site training programmes were consistently organized at the demonstration plots to enhance farmers' awareness, motivation and understanding of the demonstrated technologies and their specific benefits. Crop yield data from each farmer's demonstration plot were systematically recorded and simultaneously the yields obtained under farmers' existing practices were also documented for comparative analysis. The B: C ratio was calculated based on the net return and cost of cultivation in each treatment. The technology gap, extension gap and technology index were calculated as suggested by Samui et al (2003)

Extension gap (q/ha) = Demonstration yield (q/ha) - Farmers yield (q/ha)

Technology gap (q/ha) = Potential yield (q/ha) - Demonstration yield (q/ha)

(Technology Indx(%)= Technology gap (q /ha))/(Potential yield(q/ha))

Table 1. Comparisons of climate resilient practices and farmer practices

SN	Particular	Climate Resilient Practices	Farmers Practices
1	Variety	GNG-2144, & GNG-2171	Private Company seed
2	Land preparation	Ploughing and harrowing	Ploughing and harrowing
3	Sowing Method	Line sowing	Line sowing or boradcasting
4	Seed rate (kg/ha)	60-80	100
5	Sowing time	October first week to mid October	October first week to mid October
6	Seed treatments	Seed treatment with Trichoderma virdea 10 ml per kilogram seed followed by Azotobacter and PSB culture	Nil
7	Fertilizer dose (N:P:K)	20:40:00	Nil
8	Irrigation method	Sprinkler irrigation	Sprinkler irrigation
9	Weed management	Use of Pendimethalin @ 1 kg. a.i./ha as pre-emergence and one hand weeding	Use of Pendimethalin @ 1 kg. a.i./ha as pre-emergence
10	Plant protection measure	To control the pod borer of gram spraying of Chlotantraniliprole 18.5% SC 0.2 ml per liter of water	Indiscriminate use

RESULTS AND DISCUSSION

Number of branches per plant

The data pertaining in the Table 2 revealed that the number of branches per plant at harvest stage of chickpea under the demonstration plots recorded higher (6.8, 7.1, and 7.3) with a pooled mean of 7.07 whereas, the farmers' practices recorded 6.13 as pooled mean, respectively. The increased branches per plant might be attributed to CRP such as resilient varieties, nutrient availability and favorable microclimate created by the adoption of improved agronomic practices such as timely and line sowing and weed management (Singh et al., 2021 and Rani et al., 2022).

Number of pods per plant

The higher number of pods per plant was observed in demonstration plots compared to farmers' practices (Table 2). Among the three years the number of pods per plant was recorded 23.4, 28.4 and 31.1 whereas, the farmers; practices recorded 22.1, 26.6 and 27.9 pods per plant during the study period, respectively. This might be due to the integration of frost-tolerant varieties, efficient water management and balanced fertilization can improve pod initiation and retention in legumes under variable climatic conditions (Kumar et al., 2021; Meena et al., 2023). Climate-resilient technologies tend to enhance crop physiological efficiency and stabilize productivity even under stress-prone environments (IPCC, 2021 and Rao et al., 2022).

Grain yield (q/ha)

The grain yield was presented in data Table 3 clearly revealed that the climate-resilient practices were beneficial to increasing the chickpea yield during the years of study. The demonstrated field was observed higher yield over the farmers' practices. The CRP recorded were 13.13, 16.46 and 15.68 q/ ha whereas, the farmers' practices were noted 11.08, 13.85 and 13.60 q/ha during 2022-23, 2023-24 and 2024-25, respectively.

Table 2. Effect of climate resilient practices on number of branches and pods per plant of chickpea

Parti	Number of branches per plant				Number of pod per plant			
	2022-23	2023-24	2024-25	Pooled	2022-23	2023-24	2024-25	Pooled
Demo	6.8	7.1	7.3	7.07	23.4	28.4	31.1	27.63
FP	5.8	6.2	6.4	6.13	22.1	26.6	27.9	25.53

Under CRP improved yield might be due to

Table 3. Effect of climate resilient practices on yield and economics of chickpea crop

SN.	2022-23		2023-24		2024-25		Pooled	
	Demon	FP	Demon	FP	Demon	FP	Demon	FP
Yield (q/ha)	13.23	11.08	16.46	13.85	15.68	13.6	14.71	12.58
CoC ₹ /ha	34170	34950	38560	39850	38600	40500	35296	36286
Gross Return ₹/ha	70580	59110	89542	75344	88600	76810	78859	67397
Net Return ₹/ ha	36410	24160	50982	35494	50000	36310	43563	31111
B:C ratio	2.07	1.69	2.32	1.89	2.30	1.90	2.23	1.86

adoption of climate-resilient technologies. The improvement in yield can be attributed to multiple adaptive interventions such as the use of short-duration and frost-tolerant varieties, improved nutrient and water management and timely and line sowing practices. These measures collectively enhance crop resilience to abiotic stress which leading to better pod filling and yield realization (Rao et al., 2022 and Meena et al., 2023). Similar findings were reported by Kumar et al. (2021) who observed that adoption of integrated moisture and nutrient management practices increased the productivity of pulses under rainfed and climate-stressed conditions.

Economics

Gross and Net Returns (₹/ha)

The net and gross returns was higher under demonstration field compared to farmers' practices (FP) during the study period. The highest gross return was recorded under demonstrated field which was 89542 ₹/ha during the 2023-24 and the average of the three years was ₹78,859 /ha which was about 17% higher than under farmers' practice (₹67,397 /ha). Consequently, the average net return increased from ₹31,111 /ha (FP) to ₹43,563 /ha (Demonstration), indicating a clear economic advantage (Table 3). This improvement can be linked to enhanced crop productivity due to the resilient management practices (Patil et al., 2022 and Singh et al., 2023). These findings corroborate earlier studies showed by Chaudhary et al., 2020 and Reddy et al., 2021.

Benefit–Cost Ratio (B:C Ratio)

Table 4. Effect of climate resilient practices on extension indexes of chickpea crop

Years	No of farmers	Area (ha)	Potential yield (q/ha)	Technology gap (q/ha)	Extension Gap (q/ha)	Technology Index (%)
2022-23	20	8	22.8	9.5	2.15	42.00
2023-24	25	10	22.8	6.3	2.61	27.80
2024-25	25	10	22.8	7.12	2.08	31.20

The highest B:C ratio (2.07, 2.32 and 2.30) was recorded in 2022-23, 2023–24, and 2024-25 which was higher than the farmers' practices over the three years of study. It was possibly due to favorable climatic conditions coupled with adaptive agronomic management. The consistent improvement across all three years demonstrates the stability and sustainability of climate-resilient practices. Beyond yield enhancement, these practices contribute to risk reduction under erratic climatic conditions by optimizing resource use and maintaining soil health.

Effect of Climate-Resilient Practices on Extension Indices

The data depicted in Table 4 revealed that the extension indices of chickpea under climate-resilient practices during 2022–23 to 2024–25. These indices technology gap, extension gap, and technology index are critical in assessing the effectiveness of demonstration programs, the efficiency of technology transfer and the degree to which improved agronomic interventions bridge the productivity gap between research stations and farmers' fields.

Technology Gap

The technology gap represents the gap between the potential yield of a variety and the yield achieved in demonstration field. During the study period, the technology gap was recorded 9.5, 6.3 and 7.12 q ha^{-1}, respectively. The reduction in the technology gap over time suggests a progressive improvement in farmers' adaptation to climate-resilient technologies and better management of abiotic stresses (Kumar et al., 2021; Meena et al., 2023). The findings align also with Rao et al. (2022), who reported that consistent implementation of resilient practices can narrow the technology gap by up to 30–40% in pulse-based systems.

Extension Gap

The extension gap defined as the yield difference between demonstration technology and farmers' practices which was observed 2.15, 2.61 and 2.08 q ha^{-1} across the study years, respectively. The maximum extension gap in 2023–24 (2.61 q ha^{-1}) corresponds with a higher demonstration yield,

emphasizing the strong performance of improved technologies over conventional systems. The higher of extension gap, which motivated farmers to adopt improved climate-resilient techniques. Similar trends were documented by Singh et al. (2022) and Patel et al. (2021), they reported that adaptive interventions such as improved varieties and moisture conservation practices significantly enhanced yield differentials in frontline demonstrations.

Technology Index

The technology index which expresses the feasibility of newly introduced technologies under farmer field conditions. The lowest technology index (27.80%) recorded in 2023–24 reflects the highest level of technological feasibility, indicating that the farmers were able to adopt and realize yields closer to the potential level. Conversely, the higher index value in 2022–23 (42.00%) reflects early-stage adoption challenges and environmental variability during the initial implementation phase. A declining technology index over time signifies that climate-resilient practices are becoming increasingly feasible and acceptable among the farming community (IPCC, 2021 and Rani and Kumar, 2023).

CONCLUSION

The effectiveness of CRP and yield advantage of chickpea crop, it may be concluded that the adoption of climate-resilient practices in chickpea cultivation significantly improved yield and economic returns compared to farmers' traditional methods. The progressive reduction in technology and extension gaps and a declining technology index over three years highlighted improved adoption and feasibility of resilient technologies. These findings confirm that climate-smart interventions enhance productivity, profitability and adaptability of chickpea under variable climatic conditions.

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